UCRL-JC-124322
PREPRINT

Quantitative Precipitation and River Flow Predictions Over the Southwestern United States

J. Kim
N. Miller

This paper was prepared for submittal to the
1996 Fall Meeting of the Korean Meteorological Society
Seoul, South Korea
October 24-25, 1996

September 1996

Lawrence Livermore National Laboratory

DISCLAIMER

QUANTITATIVE PRECIPITATION AND RIVER FLOW PREDICTIONS OVER THE SOUTHWESTERN UNITED STATES

Jinwon Kim and Norman L. Miller

Univ. of California Lawrence Livermore National Laboratory, Livermore, CA 94551

1. Introduction

Accurate predictions of local precipitation and river flow are crucial in the western U.S. Steep terrain and narrow valleys can cause local flooding during short term heavy precipitation. Typical size of hydrologically uniform watersheds within the mountainous part of the western U.S. ranges 10^2 - 10^3 km^2. Such small watershed size, together with large variations in terrain elevations and a strong dependence of precipitation on terrain elevation, requires a find-resolution and well-localized NWP to improve QPF and river predictions.

The most important aspects of accurate QPF and river flow predictions in the western US are: (1) partitioning the total precipitation into rainfall and snowfall, (2) representing hydrologic processes within individual watersheds, and (3) map watershed areas onto the regularly-spaced atmospheric model grid. To improve regional scale hydrometeorological predictions, we have developed the UC-LLNL Coupled Atmosphere River Flow Simulation (CARS) system. The CARS system is currently used for an experimental NWP and seasonal hydroclimate and water resources research for the southwestern U.S. In the following, we present the QPF and river flow calculations by the CARS system during the two winter seasons from Nov. 1994 to Apr. 1995.

2. Numerical Prediction Systems

The CARS system (Fig. 1: Kim and Miller 1996, Miller and Kim 1996) is composed of the Mesoscale Atmospheric Simulation (MAS) model (Kim and Soong 1996; Soong and Kim 1996), the Soil-Plant-Snow (SPS) model (Kim and Ek 1995) , a surface hydrologic model (TOPMODEL), and Automated Land Analysis System (ALAS).

The NWP domain is covered with a 20 km x 20 km horizontal mesh with 18 σ-layers (14 σ-layers for 1994 winter). The SPS model was configured with two soil layers. We present river flow calculation at the Hopland watershed in this paper. Areas of these basins are mapped on the gridded domain using the terrain data obtained from the ALAS. The ALAS also computes hydrologic characteristics within individual watersheds that are needed by TOPMODEL.

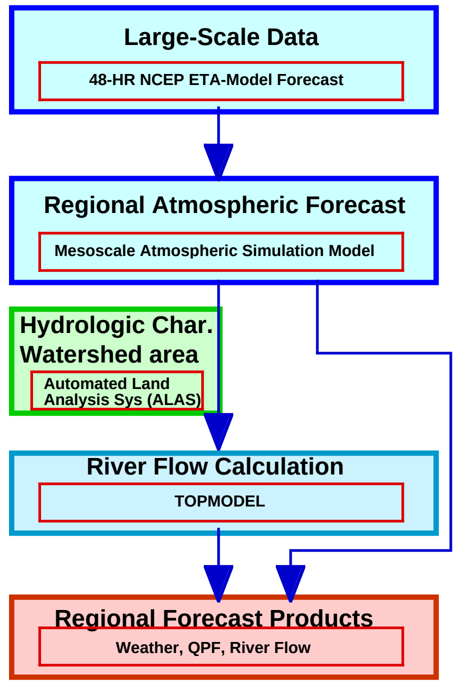

Fig. 1 The structure of the CARS system.

3. Daily Forecasts and Seasonal Simulations

Daily forecasts uses the 00UTC 80km x 80km NCEP ETA-model initial and 48-hr forecast data. This coarse resolution forecast data is interpolated onto the 20km x 20km regional NWP grid to obtain the initial condition and the large-scale tendency at the lateral boundaries at 6-hr intervals. At present, the local observations are not included in the NWP. This initial and time-dependent lateral boundary data are used to drive the fully coupled atmospheric (MAS) - land surface (SPS) model to produce the 48-hr regional NWP fields at 6-hour intervals. Then 6-hr accumulated precipitation and 6-hour mean low-level atmospheric forcing data is used as input to compute river flow. At present, we are working on two California watersheds: the Russian River and the American River basins. These watersheds are selected due to high flood potential and to the importance in the water supply, respectively. In this study, we present the results for the Russian River, the Feather River, and the Smith River watersheds. The results of the American River Headwater was presented in Kim and Miller

(1996).

The seasonal simulations are intended to evaluate the NWP system and to investigate the hydroclimate of the western US. We initialized the NWP model at the beginning of the study period (November 1994). Once initialized using the ETA-model initial fields, this seasonal simulation is continued throughout the winter by updating only the lateral boundary values as a function of time. This time-dependent lateral boundary conditions are obtained from the 12-hourly ETA-model initial fields.

4. Seasonal Precipitation Simulation

With the 12-hourly ETA-model initial fields, the CARS system well simulated the spatial and temporal variations of precipitation throughout the 1994-1995 winter season. The simulated daily-mean precipitation closely agrees with the observed values (Fig. 2). The heavy precipitation events during January and March 1995 were especially well simulated. This also indicates that the ETA model initial fields well represented the large-scale fields that affects precipitation in California.

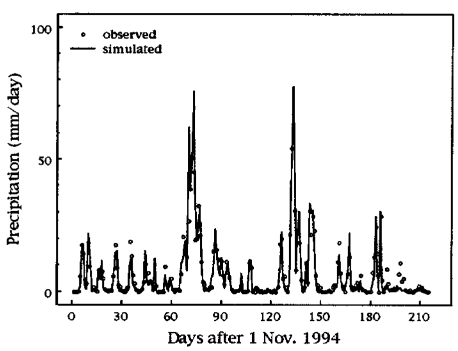

Fig. 2 Daily precipitation during 1994-1995 winter.

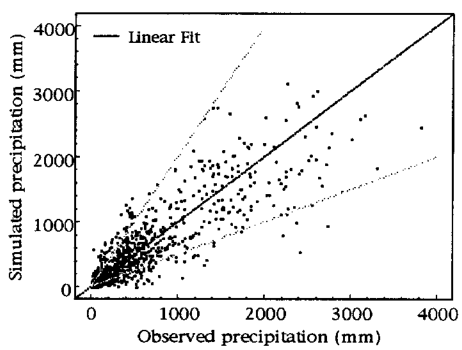

Fig. 3 Simulated and observed seasonal precipitation

The MAS model also well simulated the observed spatial distribution of the seasonal precipitation (Fig. 3). The forecast skill is higher during January and March 1995 when precipitation was heavy. During February 1995, when the precipitation was light and mostly associated with localized convection, the forecast skill was the poorest. Over the entire season, the MAS model produced precipitation is correlated with the observed values with a correlation coefficient of 0.8.

Figs. 4a and b illustrate the simulated and observed watershed-mean precipitation and river flow at the Hopland watersheds during early January 1995 flood along the Russian River. The CARS system has simulated the river flow within 10% of the observed values during the flood. The simulated river flow during low flow periods is somewhat poorer. This indicates the need for better soil and land data sets. When

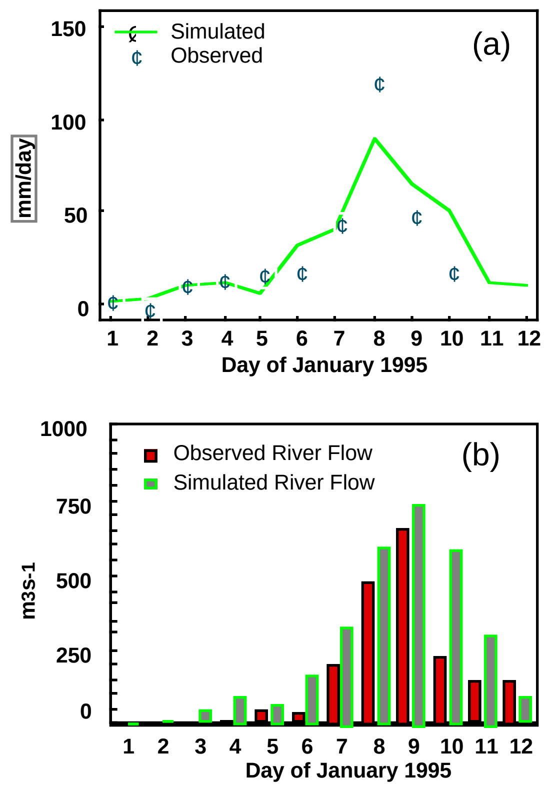

Fig. 4 Observed and simulated precipitation (a) and river flow (b) at the Hopland basin.

5. QPF at selected California watersheds

In this section, we discuss the QPF at two California watersheds, the Smith River at the northern California Coastal Range near the border with the state of Oregon and the western slope of the Feather River basin during the 1995-1996 winter season. During this season, the MAS-produced QPF consistently overestimated the observed values by 20-40%, perhaps partly due to too wet large-scale forecast data.

Despite this systematic overestimation, we could find well defined conversion factor for the both watersheds (0.75 for the Feather River western slope, 0.65 for the

Smith River). When this conversion factor was applied, the resulting QPF was correlated with the observed values with correlation coefficients of 0.82 for the Feather River western slope (Fig. 5) and 0.78 for the Smith River basin (Fig. 6), respectively. This indicates the usefulness of the regional NWP: As the forecast domain increases, it becomes more difficult to find such well defined correction factor.

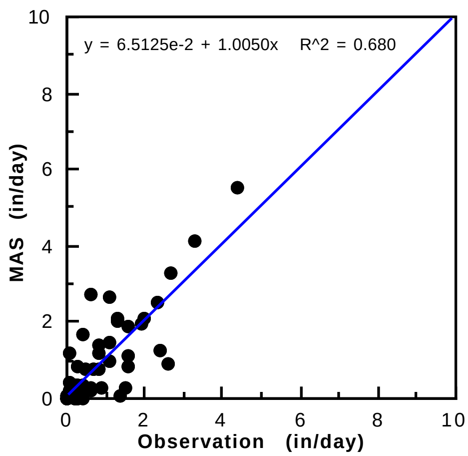

Fig. 5 A MAS-produced QPF for the western slope of the Feather River basin. A conversion factor of 0.75 is applied to the raw MAS model QPF.

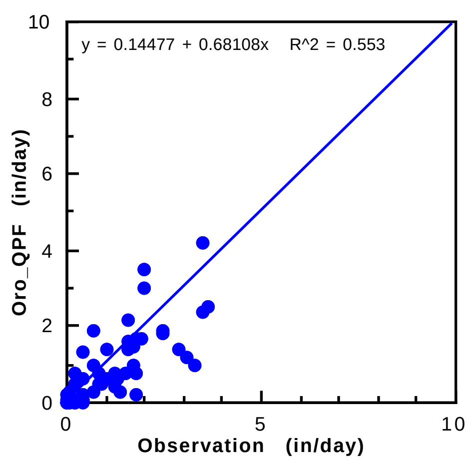

Fig. 6 Same as Fig. 5 but for the Smith River basin. A conversion factor of 0.65 is applied to the raw MAS model QPF.

6. Conclusions

A regional NWP is a useful and cost-effective tool for improving QPF and river flow predictions. The CU-CARS system well simulated the temporal and spatial variation of precipitation in California during the 1994-1995 winter season. When applied to QPF, the CARS system, despite a systematic overestimation due to too wet large-scale data, produced useful information for river flow predictions.

Acknowledgments

We thank Owen Rhea and Scott Cunningham of the NWS - CNRFC and Sacramento Office for the observed data and discussions. This work was performed under the auspices of the US DOE by Lawrence Livermore Nat. Lab. under contract No. W-7405-Eng-48.

References

Kim J. and M. Ek, 1995: A simulation of the long term surface energy budget and soil water content over the HAPEX-MOBILHY forest site. *J. Geophys. Res.*, **v. 100 (D10)**, 20845-20854.

Kim, J. and N. Miller, 1996: A coupled atmosphere-riverflow simulation in California during the 1994-1995 winter. Symposium for Environmental Appls., Jan. 28-Feb. 2, 1996, Atlanta, Georgia.

Kim J. and S Soong, 1996: Simulation of a precipitation event in the western United States. *Regional Impact of Global Climate Change*, edited by Gahn, 394pp.

Miller N. L. and J. Kim, 1996: Numerical prediction of precipitation and river flow over the Russian River watershed during the January 1995 California storms., *Bull. Ame. Met. Soc.*, **77**, 101-105.

Soong, S.-T. and J. Kim, 1995: Simulation of a heavy precipitation event in California. *Climatic Change*, **32**, 55-77.